# FINAL REPORT

## IMPACTS OF COMPOST BLANKETS ON EROSION CONTROL, REVEGETATION, AND WATER QUALITY AT HIGHWAY CONSTRUCTION SITES IN IOWA


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# PREFACE

This report summarizes the results of a three-year study sponsored by the Iowa Department of Natural Resources, and the Iowa Department of Transportation. The primary objectives of the study were to evaluate the effectiveness of using composted organics on highway construction sites to control storm water runoff and erosion, and to improve the growth of roadside vegetation.


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**Disclaimer**

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# EXECUTIVE SUMMARY

## INTRODUCTION

This project was a cooperative effort sponsored by the Iowa Department of Natural Resources (IDNR) and the Iowa Department of Transportation (Iowa DOT). Since passage of the Waste Reduction and Recycling Act in 1989, one of the main goals of Iowa's solid waste management program has been to reduce the quantity of organic wastes going into landfills. This has led to the emergence of a composting industry consisting of approximately 70 facilities throughout the State that process more than 320,000 metric tons (352,740 tons) of organics per year. To support and strengthen Iowa's organic waste recycling industry, the IDNR has established programs to evaluate potential uses and markets for composted organics.

The Iowa DOT, along with municipal and county road crews throughout Iowa, maintain an 180,000 km (112,000-mile) network of city, county, and state roadways that require constant repair and expansion. Because roadway construction temporarily disturbs large land areas, effective erosion and runoff control at road construction sites is essential. Faced with increasingly stringent federal storm water management regulations for construction sites, the Iowa DOT is particularly interested in evaluating new practices which may have potential to provide runoff control and erosion protection.

The research reported here was conducted by researchers in the Agricultural and Biosystems Engineering Department at Iowa State University to help answer questions posed by IDNR and Iowa DOT regarding potential use of composted organics to control erosion and runoff on highway construction sites in Iowa.

## SIGNIFICANCE

According to a recent national study by Mitchell (1997) at least 19 state departments of transportation have adopted specifications that permit or encourage the use of composted organics on highway construction projects. Despite widespread interest in compost use, however, there appears to be relatively little research data to verify the effectiveness of applying compost to highway construction sites. Furthermore, much of the work that has been reported has focused on the agronomic value of compost as a soil amendment rather than on compost's potential to reduce runoff and soil erosion. This research project was designed to provide baseline data that will help to determine if and how compost can be utilized for storm water and erosion control on construction projects in Iowa.

## PROJECT OBJECTIVE

The primary objective of this research project was to compare the performance of compost-treated and conventionally-treated roadway embankments. Performance parameters include runoff quantity, runoff quality, rill and interrill erosion, and seasonal growth of planted species and weeds.

## PROJECT MATERIALS AND METHODS

Three types of compost were selected for testing by the project sponsors. They included a relatively fine-textured soil-like biosolids compost, a coarse-textured mulch-like yard waste compost, and a medium-textured bio-industrial compost derived from paper mill and grain processing sludge.

These particular composts were selected for testing because the project sponsors considered them to be generally characteristic of composts that are available in substantial quantities throughout much of Iowa.

Two conventional runoff and erosion control practices that have been used by the Iowa DOT in the past provided a benchmark for evaluating the performance of the composts. These include direct seeding of erosion control vegetation into compacted roadway embankment soil or, in instances where embankment soils do not support good vegetative growth, application of a 15-cm (6-inch) blanket of imported topsoil over the embankment soil prior to seeding.

The composts were spread on the highway embankment in 5-cm (2-inch) and 10-cm (4-inch) thick blankets. The topsoil treatment was applied as a 15-cm (6-inch) blanket in accordance with long-standing Iowa DOT specifications for this practice. Neither the composts nor the topsoil were incorporated into the underlying embankment soil.

Each of the six compost treatments (3 compost types X 2 depths) and two conventional treatments was subjected to high-intensity simulated rainfall under both un-vegetated and vegetated conditions to simulate circumstances that would occur during multi-season construction projects.

Since quantity and quality of runoff are closely related to rainfall intensity, it was essential that all composts and soils be tested at the same rainfall rate. To achieve this, test plots were subjected to high intensity simulated rainfall applied using an 8-meter long (26-feet) single-sweep Norton rainfall simulator of the type used by USDA for soil erosion research. High intensity rainfall was applied at an average rate of 95 mm/hr (3.7 in/hr) for a sufficient time to cause each test plot to produce runoff for at least one hour.

During the 1st hour of runoff from each test plot, timed runoff samples were collected at 5-minute intervals. These runoff samples, or in some cases composites of these samples (see full report for further detail), were frozen and subsequently tested to determine:

- runoff rates;
- rill- and interrill erosion rates;
- total rill- and interrill erosion;
- dissolved and absorbed nutrient and metal concentrations; and
- total mass of dissolved and absorbed nutrients and metals.

## PERFORMANCE INDICES

Performance comparisons in the Executive Summary relating to the total volume of runoff, or total mass of individual pollutants contained in the runoff, are based on samples collected during the 1st 30 minutes of rainfall. As explained in the full report, similar performance indices also were calculated based on samples collected during the 1st hour of runoff. While sampling during a 1-hour runoff period is consistent with typical USDA erosion research procedures for soils, the duration of high-intensity rainfall needed to initiate and sustain runoff on the highly absorptive composts used in this study was much greater than for most soils, and considerably longer than most naturally-occurring high-intensity storms in Iowa. As a result, indices based on the 1st 30-minutes of rainfall are believed to more clearly reflect performance that is likely to occur during naturally occurring high-intensity rain storms. A more detailed discussion of performance indices is presented in the full report.

# PROJECT RESULTS

## VEGETATION

Since establishment of good vegetative cover is one of the most commonly used erosion control practices along highways, the ability of the test composts to grow a cover crop was measured and compared with conventional soil treatments. A cover crop consisting of oats, timothy, rye, and clover was planted and fertilized on the test plots according to Iowa DOT specifications.

Although the test composts generally had coarser textures and lower densities than soil, they produced as much of the planted cover crop species during two growing seasons as the topsoil or compacted subsoil. Equally important, areas treated with compost blankets exhibited significant suppression of weed growth. The total mass of weeds harvested from compost-treated areas at the end of two growing seasons was less than one-third of the weed growth on conventionally-treated areas.

## RUNOFF QUANTITY

The volume of eroded soil and water leaving interrill test plots is a useful indicator of pollution potential. Construction sites that produce less runoff have a lower potential to discharge pollutants that are carried by the eroded soil and water.

Compost treatments demonstrated excellent capacity to control construction site runoff. During the first 30 minutes of high-intensity rainfall all un-vegetated test plots treated with compost produced less than 0.2 mm of runoff while conventionally-treated (control and topsoil) plots produced more than 15 mm of runoff.

The depth of compost applications significantly affected runoff quantities. Probably as a result of increased pore volume associated with greater compost depths, runoff from 5-cm (2-inch) applications was about 1.5 times the runoff from 10 cm applications (un-vegetated conditions). Presence or absence of vegetation did not result in significant differences in runoff.

## INTERRILL EROSION

Interrill erosion is caused by raindrop impact and subsequent soil transport by a thin diffuse layer of runoff flowing over the soil surface. Sometimes called “sheet erosion,” interrill erosion ultimately leads to formation of small channels or “rills” in the soil that cause concentrated water flow and accelerated soil loss through rill erosion.

Erosion results from un-vegetated tests plots showed dramatic differences between compost-treated and conventionally-treated areas. Since compost-treated test plots produced little (if any) runoff during the initial 30 minutes of rainfall, the total mass of eroded material carried by the runoff from composted plots was less than 0.02% of that in runoff from conventionally-treated areas.

Depth of application did not significantly affect interrill erosion rates. Plots treated with 5-cm of compost performed about the same as those receiving 10-cm applications.

Type of compost affected interrill erosion rates noticeably. Yard waste compost, the coarsest and most "mulch-like" of the three composts, averaged less than 1.0% of the interrill erosion produced by the more soil-like biosolids and bio-industrial composts.

It is interesting to note that, despite the additional interrill erosion protection provided by vegetation, un-vegetated compost treatments actually outperformed the vegetated conventional treatments during this study. Loss of interrill solids (30-minute storm) was less than 8-mg on un-vegetated compost treatments, while more than 7,000-mg of eroded solids were lost from the least eroded (control) vegetated conventional treatment.

## RILL EROSION

Rill erosion is caused by concentration of runoff in small channels called "rills." Once rill erosion is initiated, increasing quantities of runoff can become concentrated in the rill channels, and considerable erosion damage can occur relatively quickly.

Rill runoff from conventional topsoil treatments contained solids concentrations that were 3.5 times higher than in rill runoff from compost treatments. There were no significant differences, however, in the solids concentrations measured in rill runoff from composts and compacted embankment soils (control). These results indicate that compost treatments are as vulnerable to rill erosion as compacted embankment conditions, but do represent some improvement over conventional topsoil treated applications.

Rill erosion results for the three composts were similar to the results of the interrill tests. Again, the coarsest compost (yard waste) performed the best, producing runoff with an average solids concentration that was less than half of the average concentrations in runoff from the other two composts.

Depth of compost application did not significantly affect rill erosion.

## ERODIBILITY FACTORS

Soil erodibility factors characterize the inherent potential for soils and soil-like materials to erode under conditions that differ from the test conditions. Erodibility factors are valuable because they permit natural resource agencies, conservation engineers, and others to prediction erosion for various types of materials under a variety of slope, rainfall intensity, and runoff conditions.

Interrill erodibility factors were successfully developed for the composts and soils and, like the other measures of interrill erosion previously discussed, they confirm that compost treatments are considerably less susceptible to interrill erosion than topsoil or compacted subsoil. In general, interrill erodibility factors for the composts were less than 1/5th of those for compacted embankment soil or topsoil treatments.

Attempts to develop rill erodibility factors and critical shear values for the composts have not been as successful. Due in part to significant differences between the physical characteristics of compost and most soils, the mathematical relationships normally used to describe rill erosion in soil do not appear to adequately characterize the rill erosion mechanisms and rill data for composts. Additional work is under way to determine if rill erodibility factors can be calculated using modified erosion models.

## WATER QUALITY

Since some types of compost contain elevated concentrations of heavy metals and/or nutrients, the chemical quality of runoff from compost-treated areas is of potential concern. Although the composts tested during this study contained higher concentrations of nutrients and selected heavy metals than the two soil treatments, none of these concentrations exceeded the maximum levels allowed by USEPA regulations for continuous land application of “high quality” biosolids.

Despite elevated concentrations of several metals and nutrients in two of the composts, runoff from compost-treated plots did not pose an increased environmental risk. In fact, with the exception of soluble phosphorus, the total mass of individual nutrients and metals detected in runoff from compost-treated plots during a 30-minute storm were significantly lower than in runoff from conventionally-treated test plots. The low total mass of both soluble and adsorbed pollutants in compost runoff was primarily the result of significantly lower interrill erosion and runoff from compost-treated areas.

## CONCLUSIONS AND RECOMMENDATIONS

Despite their differing origins, physical characteristics, and nutrient and metal content, blanket applications of all three of the composts that were tested produced excellent runoff and erosion control. As such, blanket applications of compost appears to be a potentially effective storm water and erosion management tool that can be used by engineers and planners who are responsible for storm water, erosion, and water pollution control on construction sites where large amounts of soil are temporarily disturbed.

Recognizing the added project costs of transporting and applying composts, their use is most easily justified in difficult construction situations that demand both immediate erosion and runoff control AND ability to support growth of vegetative cover. Examples include: projects that are completed too late in the growing season to establish vegetation prior to winter; projects where extremely wet or dry weather delays establishment of vegetation; areas with poor quality soils that do not support vigorous vegetative growth; or locations that are too steep or wet to reach with heavy equipment, but that can be blanketed with compost using a compost blower truck.

While the coarse yard waste compost was as resistant to rill erosion as compacted subsoil, the biosolids and bio-industrial composts showed more vulnerability to rilling. Care should be exercised when using similarly textured composts to insure that they are not placed in locations that receive concentrated flows (point discharges) of runoff. If compost blankets are placed adjacent to drainage ways or on highway foreslopes that receive concentrated runoff from traffic lanes, they should be protected with compost berms, silt fences, hay bales, or similar measures that diffuse or divert the runoff before it reaches the blanket.

On roadway embankments with standard 3 to 1 slopes, there appears to be little reason to incur the extra costs of disking or roto-tilling compost applications into the underlying soil. Prior to the first summer of rainfall simulation testing, project researchers and Iowa DOT cooperators were concerned that blanket applications of compost on 3 to 1 slopes might not remain in place when exposed to intense rainfall. Subsequent observations while applying simulated rainfall at average intensities of nearly 100 mm/hr (4 inches/hour) for periods of an hour or longer showed that the compost blankets were stable as long as they were not exposed to concentrated flow. Furthermore, the weed barrier effect of compost blankets would be substantially reduced by tilling or disking since viable weed seeds in the underlying soil would be brought to the surface where they could compete more vigorously with the desired cover crop.

In general, 5-cm (2-inch) blanket applications performed as well as 10-cm (4-inch) depths. The deeper application produced slightly less runoff, but most of the erosion, water quality, and vegetation benefits were obtained with the 5-cm (2-inch) treatments. The ability of the composts to provide these benefits with only 5-cm (2-inches) of material also provides a potential transportation cost advantage over the 15-cm (6-inch) topsoil treatments that are often used in Iowa.

Although yard waste compost performed better than the other composts in several respects, Iowa DOT representatives expressed dissatisfaction with the undesirable aesthetic aspects of the yard waste compost used in this project. Plastic bags, twine, and other visually undesirable components were the main concerns of the highway planners. In fairness to the supplier of the yard waste compost, it should be noted that this supplier can (and does) produce a screened yard waste compost of higher quality than that used in this research. The ISU researchers purposely chose to use an unscreened compost since many small composting facilities around Iowa do not have screening equipment, and the unscreened material was thought to be more representative of yard waste composts available from these smaller (but more numerous) composting operations.

Although this project was not designed to compare the economics of compost treatments with conventional site preparations, the weed suppression effect of compost blankets may provide cost benefits in situations where weed control is essential and environmental concerns dictate use of minimal herbicide applications.

## PROJECT WEBSITE

Additional information and photographs for this project are available at:

**http://www.abe.iastate.edu/compost/**